

# Chapter 3

## Peak Flow Control/ Detention Basins

Peak flow control generally involves the use of a detention structure to temporarily store excess runoff and gradually release it over a period of time to the receiving watercourse. Typically, a detention facility is designed to control outflow at a rate no greater than the pre-development peak discharge rate.

Generally, detention facilities will not significantly reduce the total volume of runoff, but will redistribute the rate of runoff over a period of time by providing

temporary "live" storage of a certain amount of stormwater. The purpose is to reduce downstream flooding and erosion problems. The most common detention structure is the dry detention basin, although wet ponds can also be used for peak flow control. This chapter focuses on detention basins, since their primary function is peak control, with little water quality benefit. Wet ponds are discussed in Chapter 4 for use as both water quality and peak flow control.

### 3.1 General Description



#### IMPORTANT

Detention basins may only be used for water quantity control. They must be combined with other water quality BMPs to receive credit for water quality improvements.

A detention basin is an impoundment designed to temporarily store runoff and release it at a controlled rate. A dry detention basin is normally designed for quantity control or peak flow control and pollutant removal is only a minimal benefit. Although detention basins are effective at controlling peak discharge rates leaving a site, they may do little to limit increases in flow rates

further downstream and, in some cases, may actually increase the peak flows at some points.

This Chapter discusses the design of detention basins for quantity control and extended detention for stream channel protection.

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Other BMPs presented in this manual (i.e., wet ponds, buffers, infiltration and underdrained soil filters) must be used for water quality improve-

ments. Figure 3-1 shows a typical detention basin.

## 3.2 Site Suitability Criteria

1. **Drainage Area:** Four acres of drainage are recommended for each acre-foot of storage in the basin.
2. **Depth to Groundwater:** The bottom of the constructed basin, including any underdrain

soil filters shall be one foot above the seasonal high groundwater table.

3. **Bedrock:** Bedrock close to the surface may prevent excavation.

## 3.3 General Design and Construction Criteria

1. **Basins on Slopes:** When basins are created by cutting and filling a slope, care should be taken that the seasonal groundwater table on the slope above the basin is not exposed, thus creating a seasonal spring. Controlling the groundwater flow or spring flow into a basin may be accomplished by the proper installation of a subsurface interceptor drainage system. To prevent destabilization from groundwater seepage, riprap may be needed.
2. **Inlet and Outlet Locations:** Provide one distinct area of inlet flow and one distinct area of outlet flow in the basin. The inlet and outlet should be as far apart as possible. Runoff should have to travel the longest distance possible through the basin before being discharged. The shallow and narrow end of the basin should be located near the inlet and the deeper and wider end near the outlet.
3. **Inlet Design:** The inlet must be designed with riprap or other energy dissipater, such as a baffle below the inflow structure to reduce erosive forces and pretreatment to remove sediment. Sediment forebays shall be designed with a minimum length to width ratio of 2:1.



### IMPORTANT

1. Runoff should travel the longest distance through the basin before being discharged.
2. Sediment forebays shall be designed with a minimum length to width ratio of 2:1.
3. Provide a maintenance right-of-way to the basin for access by heavy equipment. Maintenance access shall be planted with grass and at least 10 feet wide with a maximum slope of 15% and a maximum cross slope of 3%.
4. The maximum grade of the emergency spillway may not exceed 20% unless a non-flexible lining such as riprap is used to control erosion within the spillway.
5. A geotechnical engineer must design and submit a report on any embankment over 10' high or posing a significant hazard to downstream property or life.
6. A safety bench must be designed into all embankments greater than 10 feet high.
7. Construction of basins must be complete with side slopes and banks stabilized with grass or conservation mix seeding before allowing the basin to fill with water.
8. Basins must be vegetated by the end of the growing season or construction postponed till the next season.
9. Avoid introduction of invasive species.

4. **Relationship to Groundwater:** The basin bottom should be located above the seasonal high groundwater table to avoid standing water in the basin.
5. **Scour:** Energy dissipation should be provided at the inlet and outlet to prevent scour and reduce the velocity of stormwater. The velocity of flow through the inlet sediment control structure and basin should not exceed 2.5 feet per second.
6. **Provisions for Sediment Disposal:** Reservation of land on site for construction sediment disposal should be considered. These sites should be located such that water draining from the material could not flow directly to the water resources being protected.
7. **Access:** Maintenance access shall be planted with grass and at least 10 feet wide with a maximum slope of 15% and a maximum cross slope of 3%. This access should never cross the emergency spillway, unless the spillway has been designed for that purpose. An easement may be required.
8. **Sediment Pretreatment:** Pretreatment devices such as grassed swales, underdrained swales, filter strips, filter fabric and sediment traps shall be provided to minimize the discharge of sediment to the basin. Pretreatment structures shall be sized to hold an annual sediment loading or be routinely cleaned. An annual sediment load shall be calculated using a predicted sand application rate of 500 lbs/acre for sanding of roadways, parking areas and access drives within the subcatchment area, a sand density of 90 lbs per cubic foot and assuming a minimum frequency of ten sandings per year.
9. **Principal Spillways:** Principal spillways shall be designed to control runoff from the 24-hour storms of the 2-year, 10-year, and 25-year frequencies such that the peak flows of stormwater from the project site do not exceed the peak flows of stormwater prior to undertaking the project.
  - a. Piping Materials: Piping should be constructed of materials with a service life corresponding to the anticipated design life of the basin and its embankment. Reinforced concrete pipe is often recommended in a freshwater environment, but other materials may also be determined to be suitable.
  - b. Outlet Protection: Outflow from the basin must be directed to a stable channel. The channel should remain shaded when cold water fisheries may be impacted. The channel may need to be riprapped to prevent erosion. Riprap should be designed in accordance with the Maine Erosion and Sediment Control BMP Manual, 2003. The discharge onto a buffer needs to be spread through a level spreader designed appropriately to discharge runoff as a sheet flow. See Chapter 5 for correct design and sizing.

To obtain an annual sediment volume, perform the following calculation:

$$\frac{\text{Area to be sanded (acres)} \times 500 \text{ pounds}}{\text{acre-storm}} \div \frac{90 \text{ pounds}}{\text{ft}^3} \times \frac{10 \text{ storms}}{\text{year}} = \text{cubic feet of sediment/yr}$$

### 3.4 Surface Detention Basin Design Criteria

In addition to the general design and construction criteria, the following criteria apply to surface detention basins.

1. **Basin Slopes:** Basin side slopes must be no steeper than 2:1. Flatter slopes provide easier access and maintenance (mowing) of the basin. At a minimum, one side slope, interior or exterior, must be 3:1, such that the combined interior and exterior embankment should total 5:1 (2:1 + 3:1).
2. **Basin Shape:** Provide a long and narrow basin shape, with a minimum length to width ratio of 2:1, 3:1 is best. Length to width ratio can be increased by designing an irregularly shaped basin or by using baffles to create a longer path of flow. The basin should be narrowest at the inlet and widest at the outlet.
3. **Inlet Protection:** Prevention of scour at the inlet is necessary to reduce maintenance problems and prevent damage to basin floor vegetation. Provide energy dissipation at the inlet in accordance with practices outlined in the Maine Erosion and Sediment Control BMPs Handbook (March 2003).
4. **Emergency Spillways:** Emergency spillways shall be designed to independently convey the routed runoff from at least the 25-year, 24-hour storm while maintaining at least one foot of freeboard between the peak storage elevation and the top of the embankment crest and to safely convey the 100-year storm without overtopping the embankment. Overflow must discharge to a stable channel or established wetland area.
  - a. Location: Emergency spillways must be located on undisturbed, non-fill soil wherever possible. If the spillway must be located on fill soils, then it must be horizontally offset at least 20 feet from the principal outlet and be designed with a riprap lining, reinforced-turf lining, or a non-flexible lining.
  - b. Exit channel grade: The maximum grade of the spillway's exit channel may not exceed 20% unless a non-flexible lining is used to control erosion within the channel. Vegetation, reinforced turf, riprap, and modular blocks are considered flexible linings. All linings must be evaluated for stability at the channel grade chosen. There shall be no large woody species growing in the emergency spillway that could interfere with its function.
  - c. Flow depth: The design flow depth in the exit channel may not exceed one-half the d50 stone size for channels lined with riprap and three inches for channels lined with un-reinforced vegetation. The channel shall be designed to remain stable through the full range of design flows.
4. **Embankments:** Embankments must be designed by a professional engineer registered in the State of Maine. The embankment must be designed to meet engineering standards for foundation preparation, fill compaction, seepage control, and embankment stability. Standards for small embankment ponds and basins can be found in Section G-2 of the Maine Erosion and Sediment Control BMPs Handbook (March 2003). The design must include an investigation of the subsurface conditions at the proposed embankment location to evaluate settlement potential, groundwater impacts, and the need for seepage controls. The department will require the submittal of a geotechnical report from a geotechnical engineer for any embankment over 10 feet in effective height or posing a significant hazard to downstream property or life.
  - a. Key: Embankments must be keyed into undisturbed subsurface soils.
  - b. Crest elevation: The minimum elevation of the top of the settled embankment must be at

least one foot above the peak water surface in the basin with the emergency spillway flowing at design depth for the design storm routed through just the emergency spillway.

- c. **Crest width:** The minimum crest width for any embankment must be as shown in the following table:

Effective Height of Embankments (feet)	Crest Width (feet)
Less than 10	6
10-15	8
15-20	10
20-25	12
25-35	14
More than 35	15

- d. **Fill Material:** Fill must be free of frozen soil, rocks over six inches, and sod, brush, stumps, tree roots, wood, or other perishable materials. Embankment fills less than 10 feet in fill height must be compacted using compaction methods that would reasonably guarantee that the fill density is at least 90% of the maximum density as determined by standard proctor (ASTM-698). All embankment fills more than 10 feet in fill height must be compacted to at least 90% of the maximum density as determined by standard proctor (ASTM-698) and must have their density verified by field density testing.

- e. **Slopes:** The embankment's slopes may not be steeper than 2:1. For safety reasons and to promote vegetation growth, a gradually sloped embankment around the basin perimeter is recommended. Flatter slopes provide easier access and maintenance (mowing) of the basin. At a minimum, one side slope, interior or exterior, must be 3:1, such that the combined interior and exterior

embankment should total 5:1 (2:1 + 3:1). Riprap can also be installed around the edge of the basin in accordance with SCS guidance.

5. **Construction:** Construction can be started no later than September 1 or earlier than June 1. If sideslopes and banks cannot be revegetated and stabilized by the end of the growing season, basin construction should be delayed to the following growing season. Construction of basins should be planned so as not to take more than 1 to 2 weeks, excluding major weather delays. Seeding must occur by September 15 or other stabilization measure must be implemented in preparation for the winter season.

6. **Discharge to Basin:** Do not discharge stormwater to the basin until the basin is fully stabilized or provide a sediment barrier at the outlet.

7. **Floor Compaction:** Provide a means to prevent soil compaction on the floor of the basin during construction.

8. **Soil Amendment:** If the basin soil needs amendment to support vegetation, the added material needs to be at least 6 inches thick with the bottom 3 inches rototilled into the native soils. Wood waste compost and other highly organic material work best.

9. **Naturalized Basins:** Naturalized basins shall be used in lieu of conventional detention basins wherever feasible. In addition to conventional design criteria, the following design criteria shall be followed to achieve the maximum benefit:

- a. **Low Flow Channel:** Construct basin to have a natural low flow channel with turf reinforcement material to remove pollutants and prevent erosion.

- b. **Landscaping:** Incorporate a naturally landscaped area at the ground surface. The ground surface around the basin shall be

large enough to be in scale with the overall landscaped area. The purpose is to filter and soften views from residential areas. Group trees or shrubs to avoid a spotty effect. A minimum of six inches of topsoil with at least 6% organic content shall be provided for all planting ground cover beds or lawn areas.

- c. **Vegetation:** Plant all areas of the naturalized basin, including basin floors, side slopes, berms, impoundment structures, or other earth structures, with suitable vegetation such as naturalized meadow plantings or lawn grass specifically suited for storm water basins. Suggested plants include:
  - i. Grasses: Big Blue Stem, Switchgrass and wildflower mixes. In wet areas, plant Sweetflag, Yellow Iris and Soft Rush for color and texture.
  - ii. Shrubs: Red Chokeberry (*Aronia arbutifolia*), Silky Dogwood (*Cornus amomum*), Arrowwood (*Viburnum Dentatum*), Cranberrybush (*Viburnum trilobum*).
  - iii. Trees: Red Maple (*Acer rubrum*), River Birch (*Betula nigra*), Sweetgum (*Liquidambar styraciflua*), various Willows. Trees may not be planted below the pool area of the basin. If shrubs are used, they must be adapted to wet or moist soils conditions.
- d. **Mulch:** Mulch all shrub beds located within the pool area with a non-floating type mulch over a weed barrier material.
- e. **Maintenance Access:** Blend access area in with the surrounding landscape to the extent feasible.
- f. **Basin Shape:** The perimeter of all basins shall be curvilinear so that from most edges of the basin, the whole basin will not be in view. A more traditionally shaped (oval or rectangular) basin may be permitted when conditions



### IMPORTANT Design Tips - Vegetation

Seed mixtures must be appropriately selected for the soil type, moisture content, the amount of sun exposure, and the level of use as found at the site. Examples are as follows:

**Lots of sun and mostly dry:** Creeping red or tall fescue, perennial rye grass and clover

**Shady areas:** Creeping red fescue, Kentucky bluegrass, Canada bluegrass

**Wetlands:** Creeping red fescue, Reed canary grass, Timothy

**Steep slopes:** Crownvetch, clover

#### Naturalized basins:

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**Shrubs:** Red Chokeberry (*Aronia arbutifolia*), Silky Dogwood (*Cornus amomum*), Arrowwood (*Viburnum Dentatum*), Cranberrybush (*Viburnum trilobum*)

**Trees:** Red Maple (*Acer rubrum*), River Birch (*Betula nigra*), Sweetgum (*Liquidambar styraciflua*), various Willows. Trees may not be planted below the pool area of the basin. If shrubs are used, they must be adapted to wet or moist soils conditions

The mixture should include some annual rye for quicker green-up. Apply at the approximate rate of 0.5 -1 lbs per 1,000 SF (30-50 lbs per acre). Contact your Soil and Water Conservation District for specific mixtures.

such as topography, parcel size, or other site conditions warrant. Basins shall follow natural landforms to the greatest extent possible or be shaped to mimic a naturally formed depression.

- 10. Vegetation:** Plant all areas of the basin, including basin floors, side slopes, berms, impoundment structures, or other earth structures, with grasses such as naturalized meadow plantings or lawn grass specifically suited for stormwater basins. Six inches of loam or composted wood waste or fine erosion control mix should be added if necessary to amend onsite soils.

Particular care must be used to avoid the unintended introduction of invasive species such as purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*). It is recommended that a qualified wetland biologist be consulted when planning the revegetation of a basin.

### 11. Principal Spillways:

- a. Trash Racks: All basin outlets must have a trash rack to control clogging by debris and

to provide safety to the public. The surface area of each rack must be at least four times the outlet opening it is protecting. The spacing between rack bars must be no more than six inches or one-half the dimension of the smallest outlet opening behind it, whichever is less. Trash racks should be inclined to be self-cleaning.

- b. Seepage Controls: All pipes that extends through an embankment should have anti-seep collars or filter diaphragms to control the migration of soil materials and, so, prevent potential embankment failure from "piping" within the backfill soil along the conduit. All smooth outlet pipes greater than eight inches and all corrugated outlet pipes greater than 12 inches must have seepage controls to prevent the migration of soil along the outside of the pipe.
- c. Anti-floatation: All outlets employing a riser structure must be designed to prevent the riser floating.

## 3.5 Subsurface Detention Basin Design Criteria

In addition to the general design and construction criteria, the following criteria apply to subsurface detention basins.

- 1. Emergency Spillways:** Emergency spillways shall be designed to independently convey the routed runoff from at least the 25-year, 24-hour storm. Overflow must discharge to a stable channel or established wetland area.
- 2. Pretreatment:** All subsurface systems must include pretreatment for the removal of sediments prior to entering the detention structure.
- 3. Observation Wells:** Subsurface detention systems must have an observation port for monitoring sediment levels and determining when rehabilitation is necessary. This should be installed to the bottom of the system. The observation well shall be a 4-inch diameter, perforated PVC pipe fitted with a removable yet securable well cap, foot plate, and rebar anchor. Set the observation well prior to backfilling with the stone fill.
- 4. Access Ports:** Access to the subsurface system must be provided to allow for the removal of accumulated sediments.

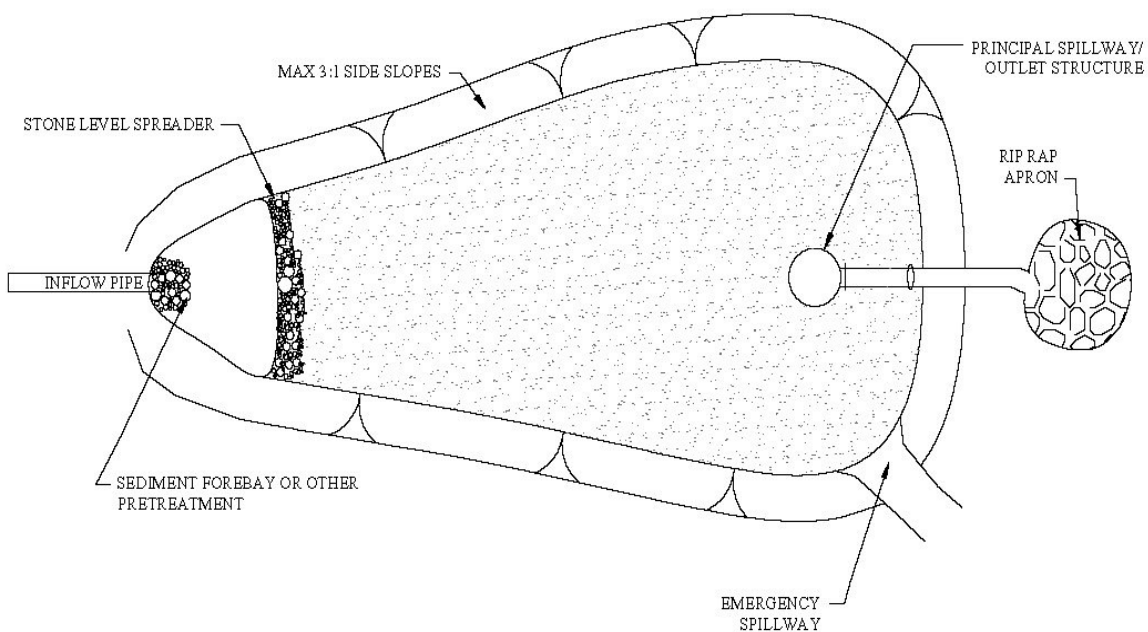
## 3.6 Maintenance Criteria

1. **Maintenance Agreement:** A legal entity should be established with responsibility for inspecting and maintaining any detention basin. The legal agreement establishing the entity should list specific maintenance responsibilities (including timetables) and provide for the funding to cover long-term inspection and maintenance.
2. **Inlet & Outlet Inspections:** The inlet and outlet of the basin should be checked periodically to ensure that flow structures are not blocked by debris. Inspections should be conducted monthly during wet weather conditions from March to November. It is important to design flow structures so that they can be easily inspected for debris blockage, and that corrective action can be taken even during storm conditions.
3. **Erosion & Instability:** Basins should be inspected annually for erosion, destabilization of side slopes, embankment settling and other signs of structural failure, and loss of storage volume due to sediment accumulation. Corrective action should be taken immediately upon identification of problems.
4. **Embankment Maintenance:** Embankments should be maintained to preserve their integrity as impoundment structures, including, but not necessarily limited to, vegetative maintenance (mowing, control of woody vegetation), rodent control, erosion control and repair, and outlet control structure maintenance and repair. Basins should be mowed no more than twice a year during the growing season to maintain maximum grass heights less than 12 inches. All accumulated trash and debris shall be removed.
5. **Sediment Removal:** Sediment should be removed from the pretreatment structure at least annually and from the basin when necessary.
6. **Observation Wells, Measure of Sediment Accumulation, and Points of Access for Sediment Removal:** Observation wells and access points to allow for the inspection and removal of accumulated sediment must be included in the design of subsurface systems. The maintenance plan must provide for removal of sediment from the infiltration system.
7. **Improving Maintenance:** A shallow detention basin designed to be used for other purposes, such as recreation, is more likely to be well-maintained.

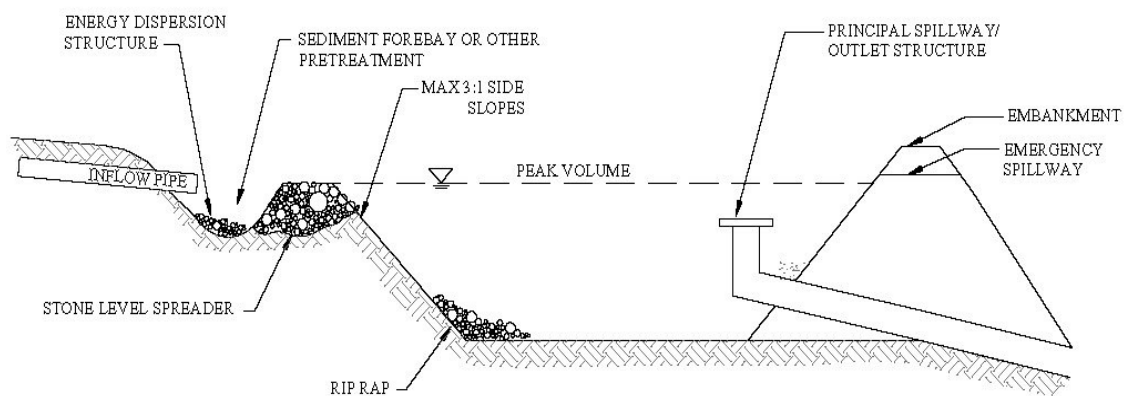
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## Selected References

Maine DEP. 2003. *Maine Erosion and Sediment Control BMPs*. Bureau of Land and Water Quality and Maine Department of Environmental Protection.

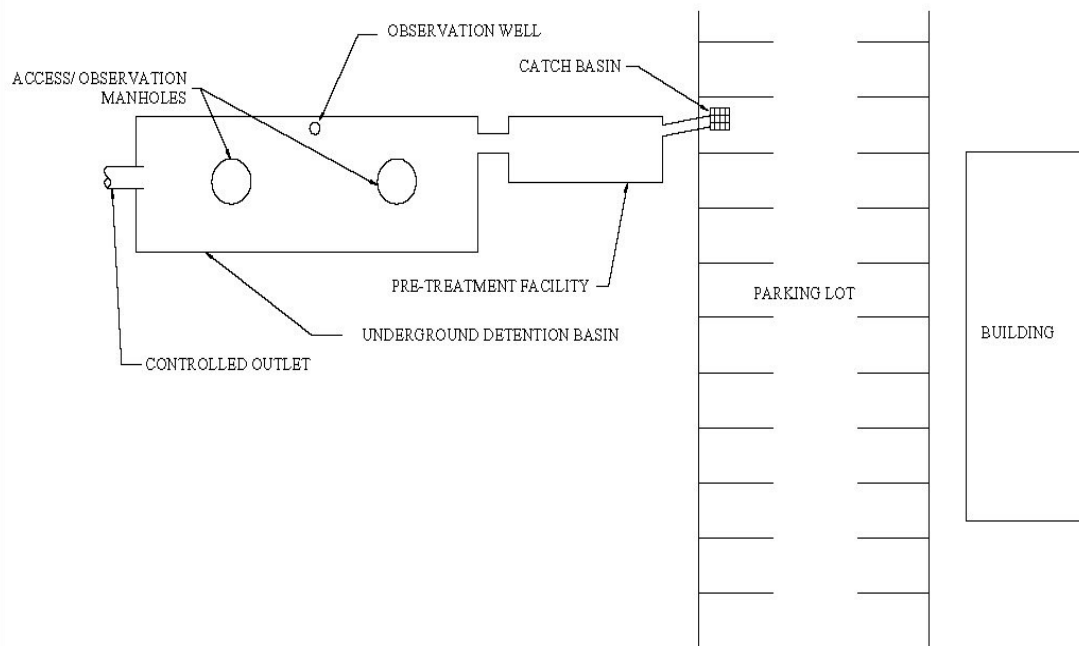


PLAN VIEW

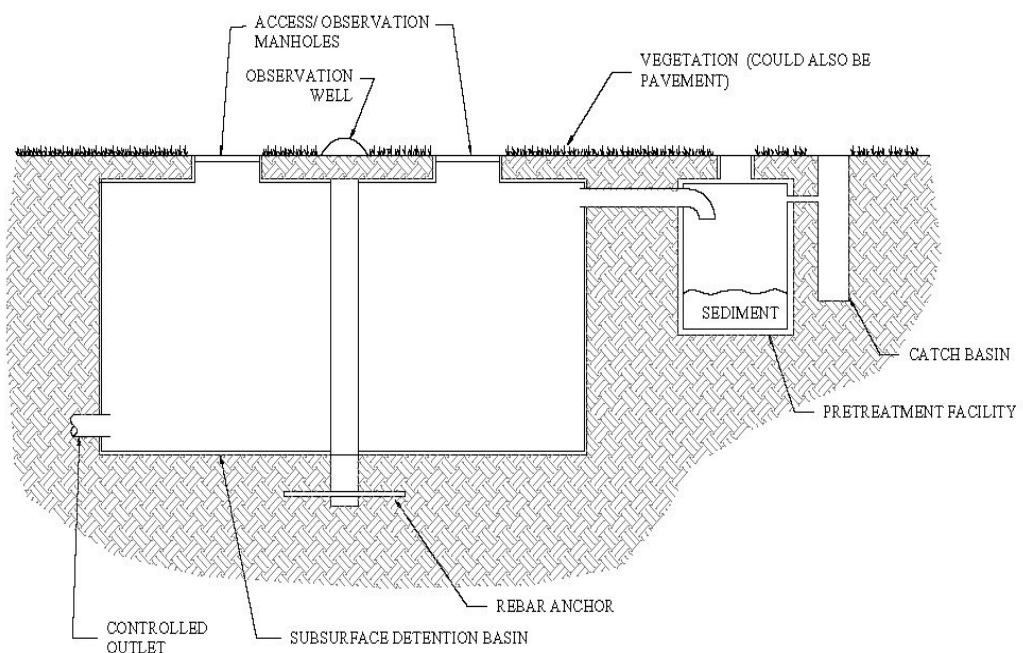


PROFILE

FIGURE 3-1. TYPICAL DETENTION BASIN



PLAN VIEW



CROSS-SECTION

FIGURE 3-2. TYPICAL SUBSURFACE DETENTION BASIN